Search for Supersymmetry

Search for electroweak production of supersymmetric states in Non-Universal Higgs Mass model with two extra parameters compressed scenario with the ATLAS detector

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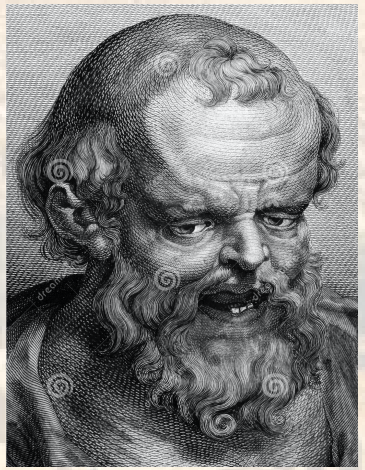
Ancient Greece...

History

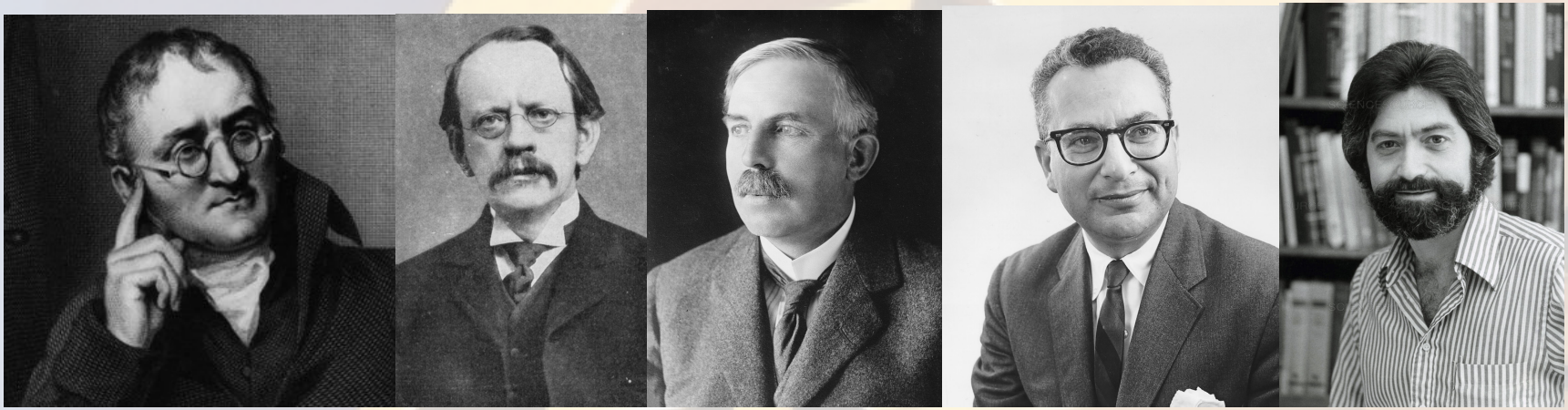
- Aristotle:
  - All materials on Earth were made of the four elements: Earth, Fire, Water, and Air
  - All substances were made of small amounts of these four elements of matter
- 460 - 370 B.C. Democritus:
  - All matter consists of invisible particles called atoms
  - Atoms are indestructible
  - Atoms are solid but invisible
  - Atoms are homogenous
  - Atoms differ in size, shape, mass, position, and arrangement
    - ★ Solids are made of small, pointy atoms
    - ★ Liquids are made of large, round atoms
    - ★ Oils are made of very fine, small atoms that can easily slip past each other



20 Century...

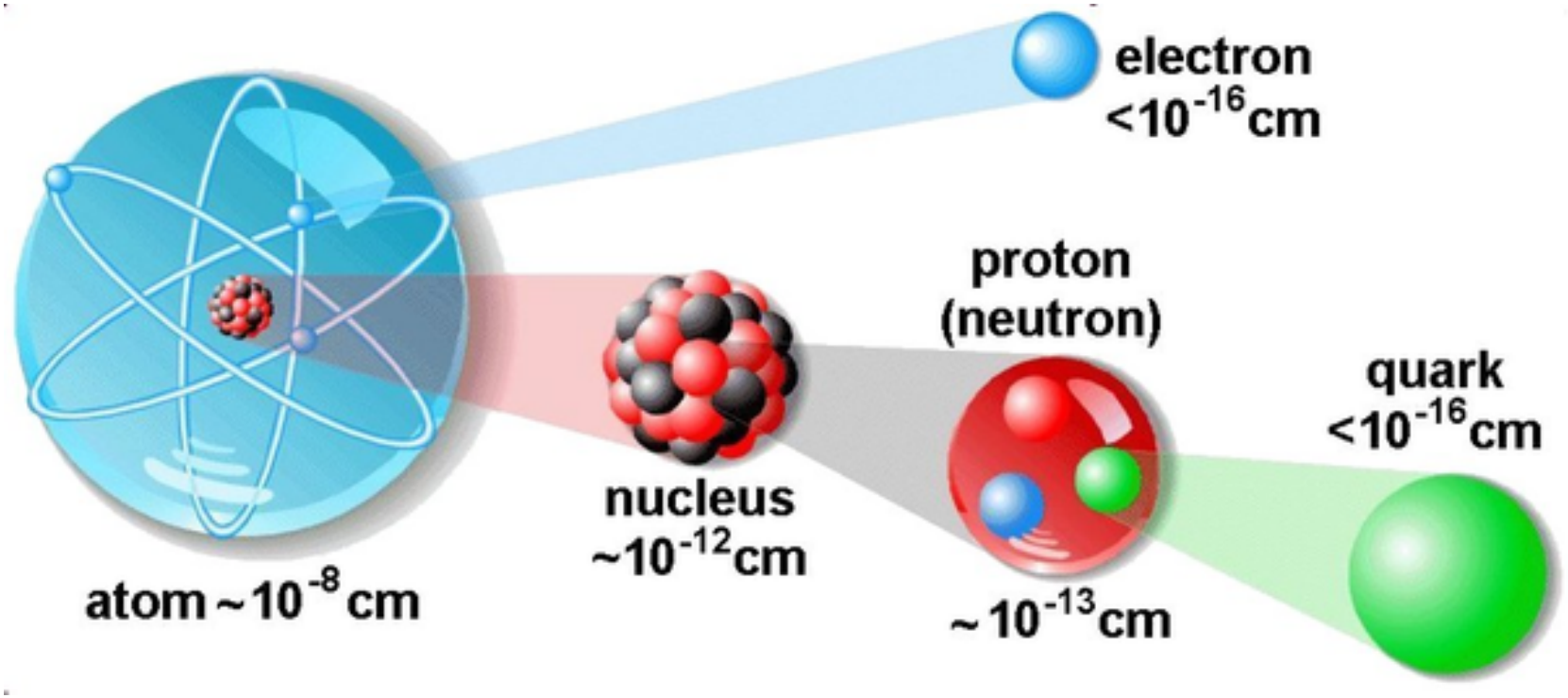
History

- 1803 John Dalton:
  - Elements are made of extremely small particles called atoms
  - Atoms cannot be subdivided, created or destroyed
- J.J Thomson discovered electrons and proposed the Plum pudding model in 1904
- Rutherford discovered atomic structure in 1909
- Gell-Mann and Zweig proposed quark model in 1964 and quarks were observed in 1968.



History

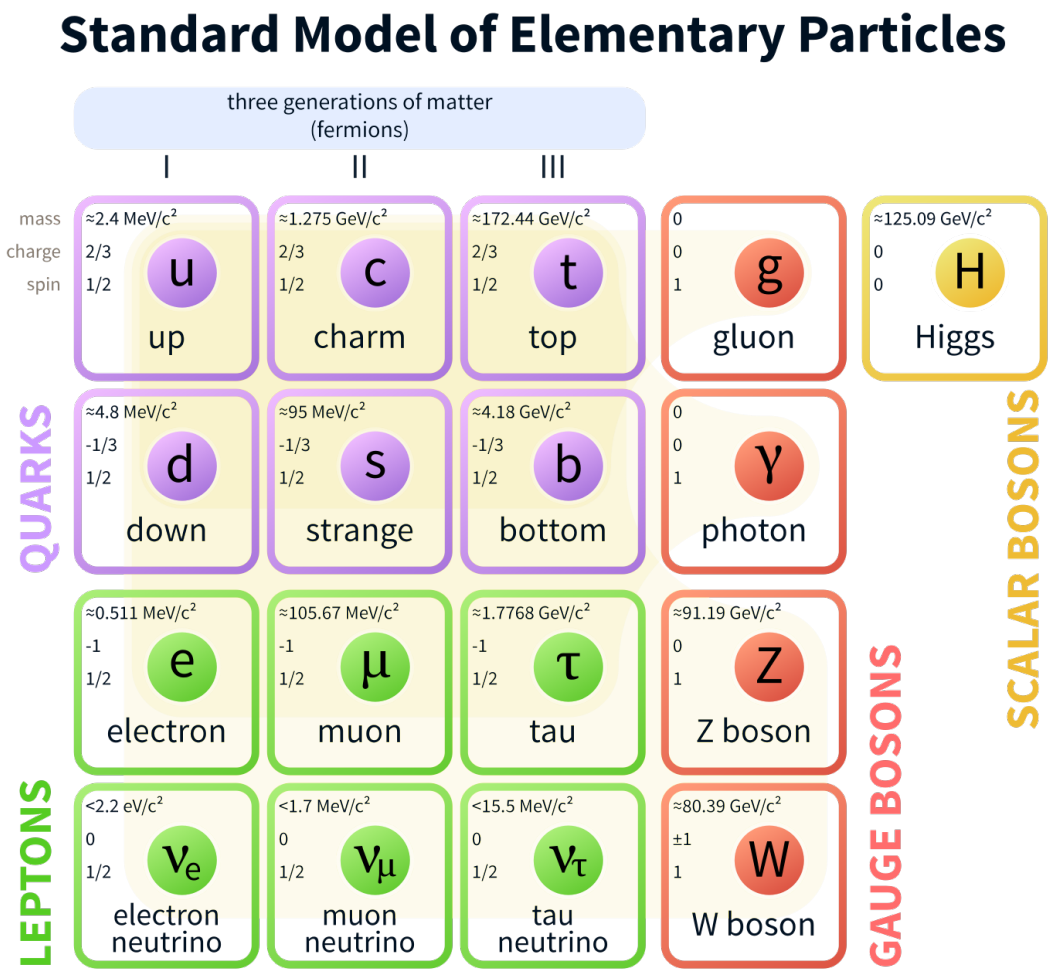
- The atomic structure we know now:

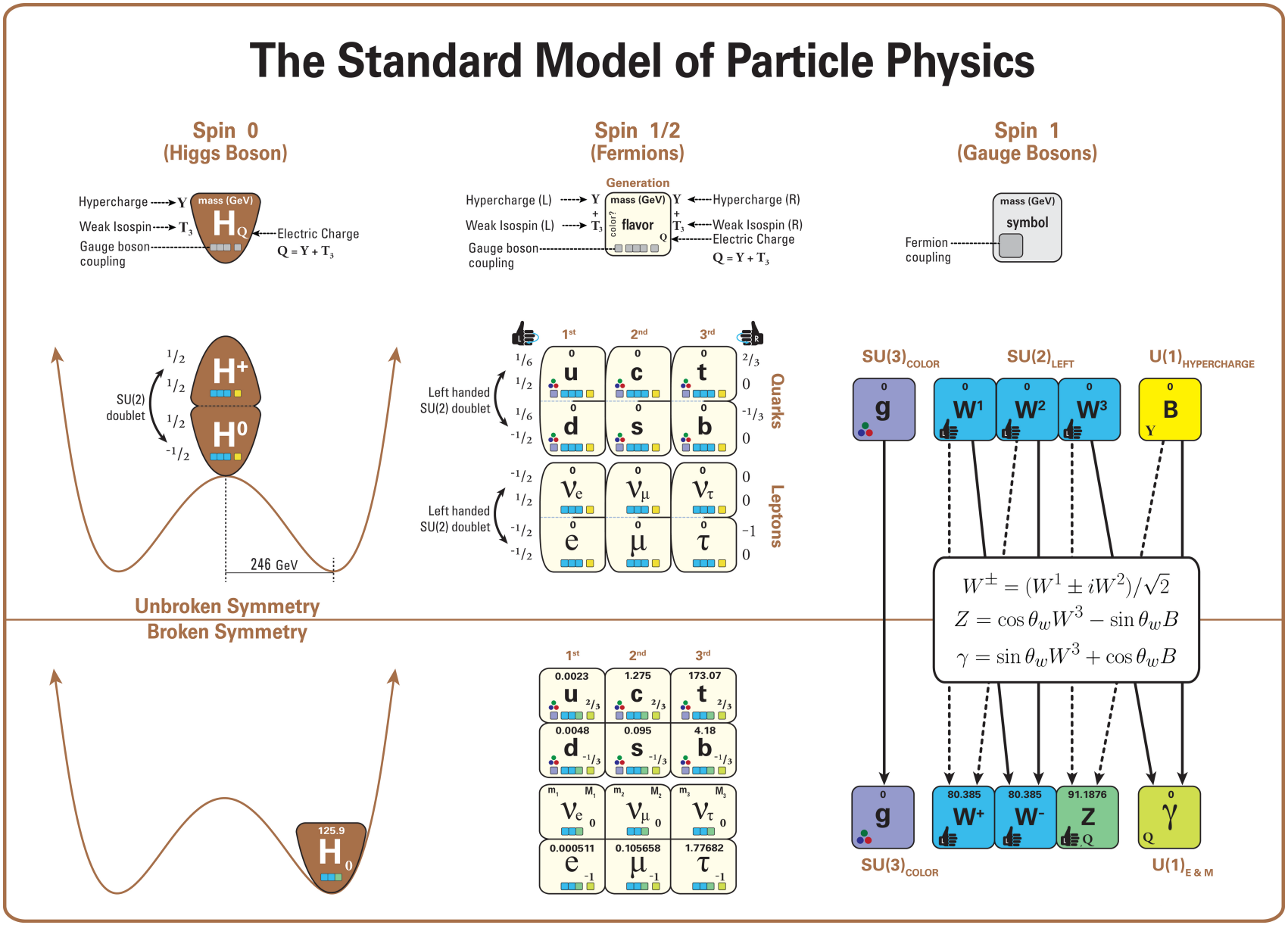


Standard Model of Particle Physics

- The Standard Model of particle physics describes current understanding of fundamental particles and their interactions

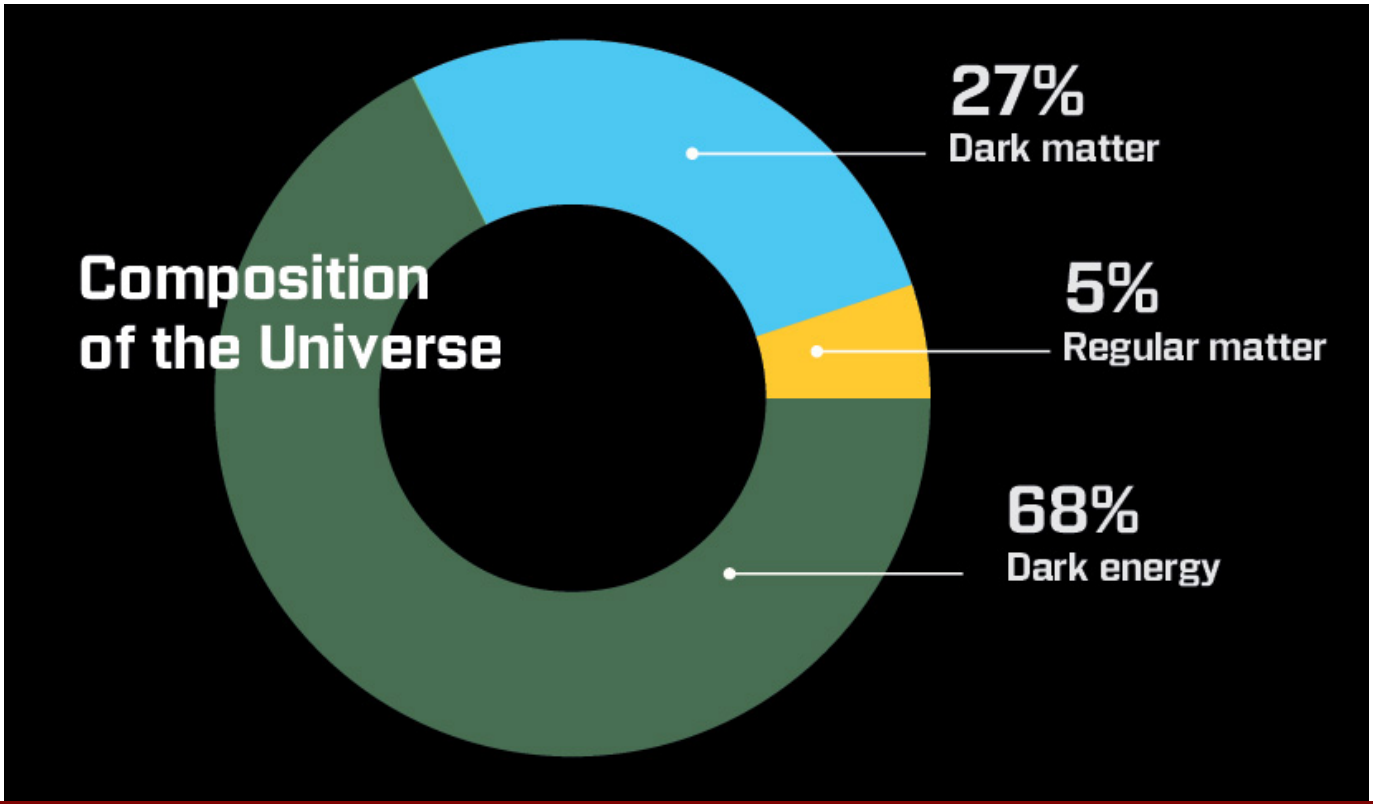
- 3 principles
  - Special Relativity
  - Quantum Mechanics
  - Gauge Invariance: $SU(3) \otimes SU(2) \otimes U(1)$
- 2 catogeries
  - Ferminos: spin 1/2 matter particles
  - Bosons: integer spin force carriers
- Higgs boson
  - Discovered in 2012
  - Gives mass to fundamental particles
  - Spontaneous symmetry breaking




The Standard Model of Particle Physics
Spin 0
(Higgs Boson)
Hypercharge
Y
mass (GeV)
H_Q
Weak Isospin
T_3
Gauge boson coupling
Electric Charge
$Q = Y + T_3$
Spin 1/2
(Fermions)
Generation
Hypercharge (L)
Weak Isospin (L)
Gauge boson coupling
mass (GeV)
color?
flavor
Q
Hypercharge (R)
Weak Isospin (R)
Electric Charge
$Q = Y + T_3$
Spin 1
(Gauge Bosons)
Fermion coupling
mass (GeV)
symbol
SU(2) doublet
H^+
H^0
246 GeV
Unbroken Symmetry
Broken Symmetry
1st
2nd
3rd
Left handed SU(2) doublet
u
c
t
d
s
b
Quarks
ν_e
ν_μ
ν_τ
e
μ
τ
Leptons
0.0023
1.275
173.07
0.0048
0.095
4.18
0.000511
0.105658
1.77682
125.9
H
0
SU(3)COLOR
SU(2)LEFT
U(1)HYPERCHARGE
g
W1
W2
W3
B
$W^{\pm} = (W^1 \pm iW^2)/\sqrt{2}$
$Z = \cos\theta_w W^3 - \sin\theta_w B$
$\gamma = \sin\theta_w W^3 + \cos\theta_w B$
80.385
80.385
91.1876
W+
W-
Z
γ
SU(3)COLOR
U(1)E & M

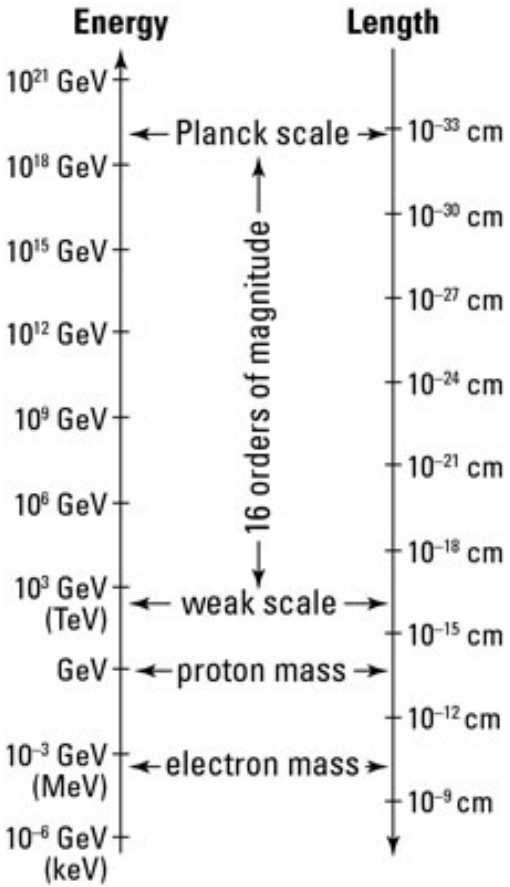
Open questions of the SM

- The SM cannot explain: hierarchy problem, the Dark Matter & Dark Energy, Grand unification, etc..
- Example: Dark Matter & Dark Energy
  - Dark Matter doesn't absort, emit, and relect light
  - Dark Energy distributes throughout the universe
  - Cosmological data hints the presence of dark matter and dark energy

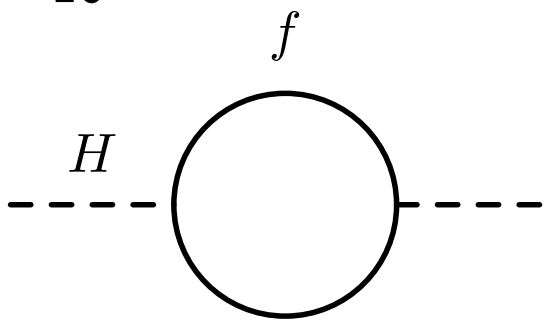


Open questions of the SM

- The Standard Model is valid up to the Plank scale.
- The fundamental parameters of the Standard Model don't reveal anything about these scales of energy

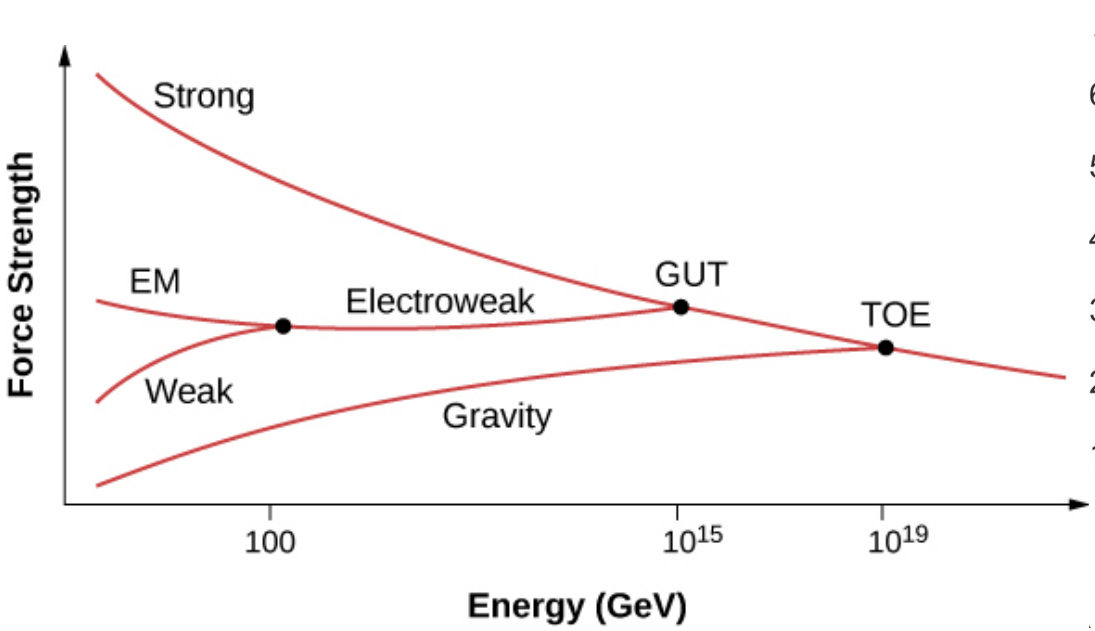


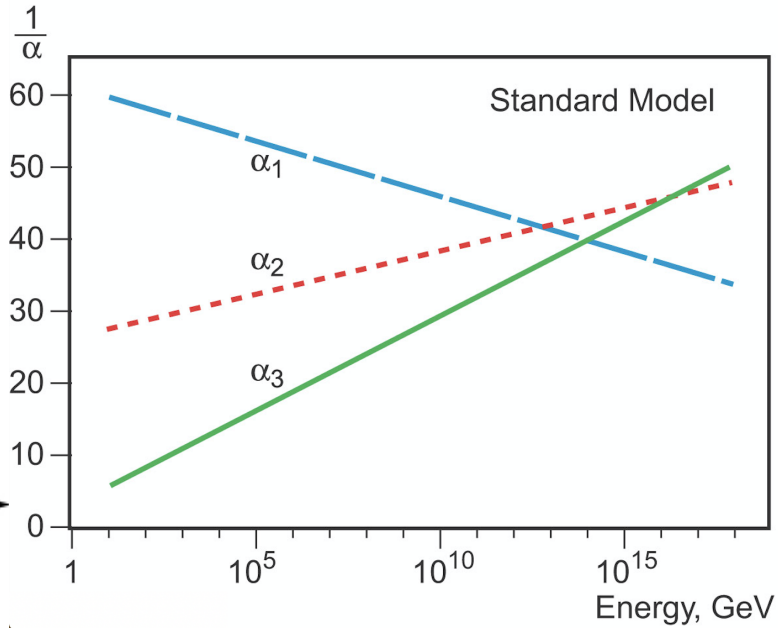
- Hierarchy problem:
  - Big gap in the energy scale
  - Weak scale and Plank scale: $\sim 10^{16}$
  - Weak force and gravational force: $\sim 10^{24}$
- Higgs mass: $m_H^2 = m_{bare}^2 + \delta m_H^2$
  - $m_H \sim 125$ GeV
  - $\delta m_H^2 = -\frac{|\lambda_f|^2}{8\pi}\Lambda_{UV}^2$ is quadratically divergent
    At Plank scale $\Lambda_{UV}^2 \sim 10^{19}$ GeV
    $\Rightarrow \delta m_H^2 \sim 10^{38}$



Open questions of the SM

- Grand Unification Theory (GUT) expects:
  - Electromagnetic, weak, and strong forces unify at GUT scale ($\sim 10^{16}$ GeV)
  - Coupling constants α_1, α_2, and α_3 converge





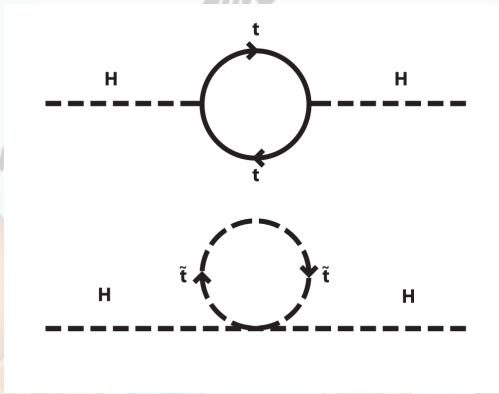
- Coupling constants do not converge in the SM

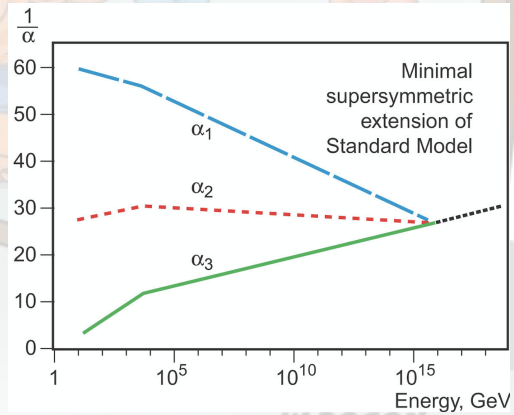
Supersymmetry (SUSY)

- Proposed by Wess and Zumino in early 1970
- Introduce supersymmetric partner particle to each SM particle
- Super particles have exactly the same quantum number as their SM partner particles except the spin differ by $\frac{1}{2}$

$$\text{Boson} \Longleftrightarrow \text{Fermion}$$

- SUSY answers:
  - The hierarchy problem: opposite-sign loop corrections from SUSY particles
  - The candidate of Dark Matter: Lightest SUSY Particle (LSP)
  - Coupling constants converge at GUT scale
  - and more





Experimental Apparatus

The Large Hadron Collider (LHC)

ATLAS Detector

Section 3

Conclusion

Conclusion

- A slide
- with a title
- and some bullets